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Fish ladder as connectivity in a large Neotropical river: upstream and downstream movements of Prochilodus lineatus

Dr. Leandro F. Celestino

Fish ladder as connectivity in a large Neotropical river: upstream and downstream movements of *Prochilodus lineatus*

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etech
Grupo de Pesquisa em Tecnologia em Ecohidráulia e Conservação de Recursos Pesqueiros e Hídricos
Unioeste - *Campus* Toledo/PR

LATECH
Laboratório de Ecohidráulica e Hidrobiologia

- Worldwide there are thousands dams taller than 15 m (Zarfl, et al 2015);
- Dams cause interruption of : - Longitudinal river gradient (Junk et al 1989; Skalak et al 2013);
  - Nutrient dynamics (Vannotee et al 1980);
  - Connectivity (Wilkes et al 2017);
- Severe impact on aquatic biota (Johnson et al 2008; Taylor et al 2014);
  - This problem is still increasing;
  - (ICOLD, 2016; Zarfl et al 2015);

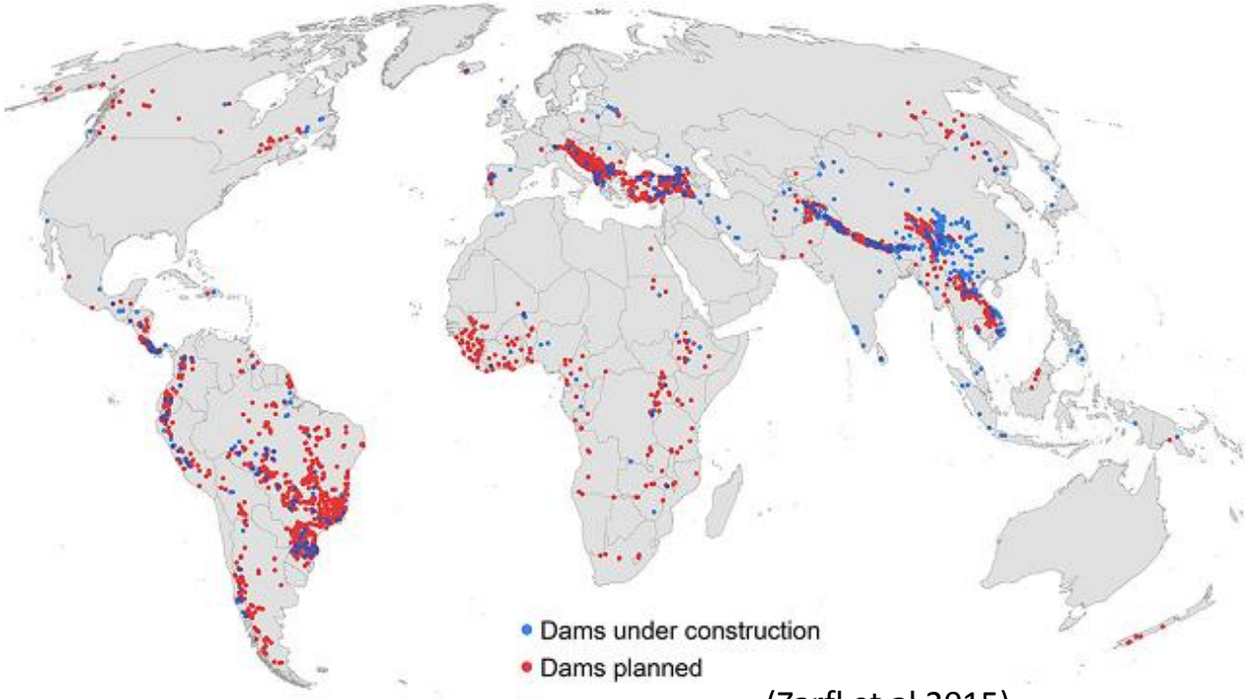
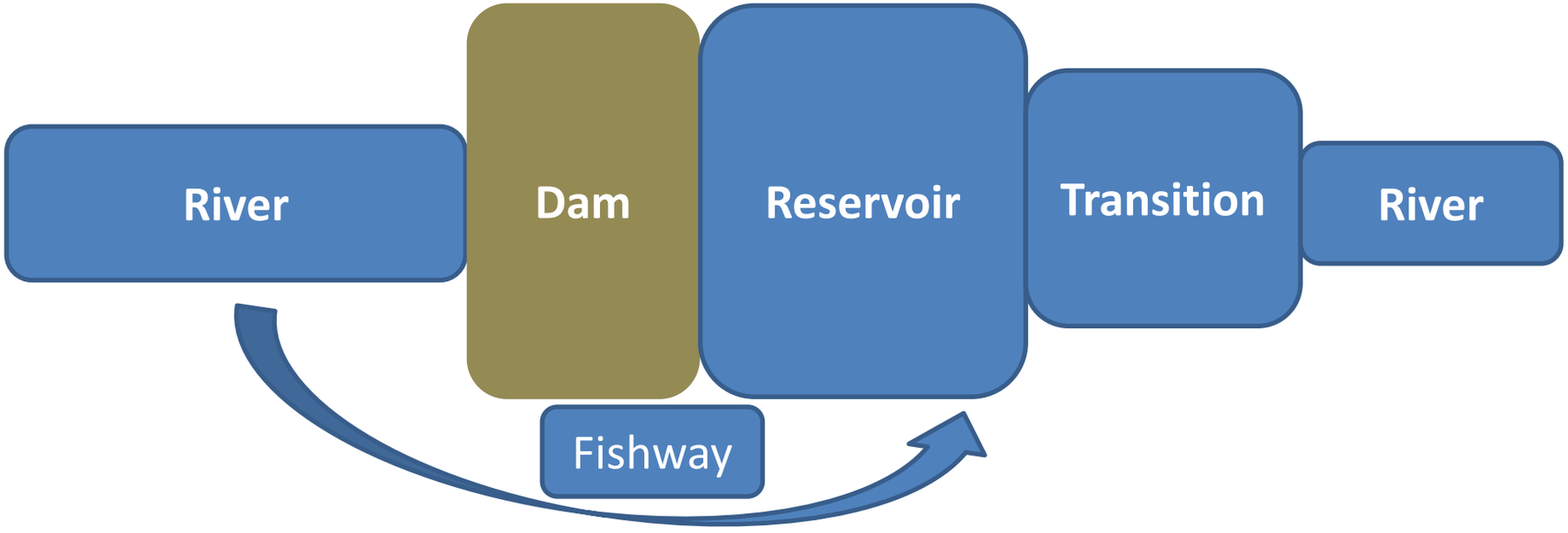


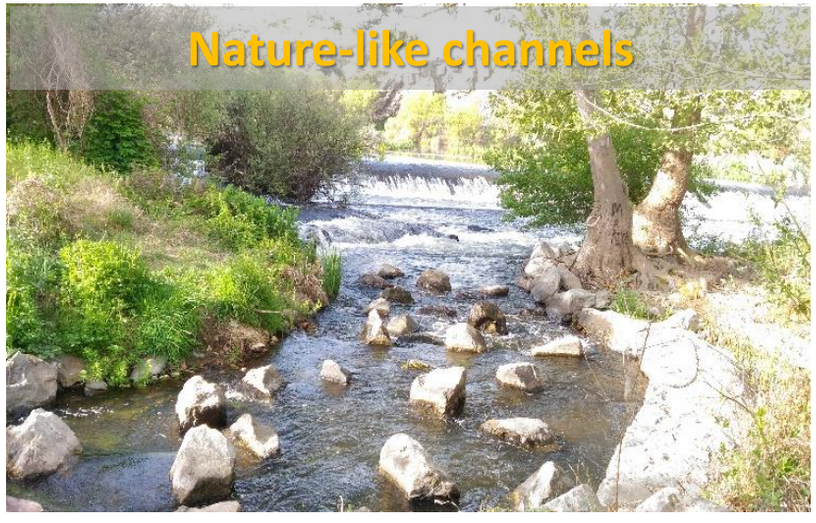
Fig. 2 Global spatial distribution of future hydropower dams, either under construction (*blue dots* 17 %) or planned (*red dots* 83 %)

(Zarfl et al 2015)


River
Dam
Reservoir
Transition
River
Fishway


Fish lifts


Fish ladders


Nature-like channels


Fish locks

- Fish ladder described as partially effective:
  (Agostinho et al 2011; Krabool et al 2009);

  - For no provides downstream passage.

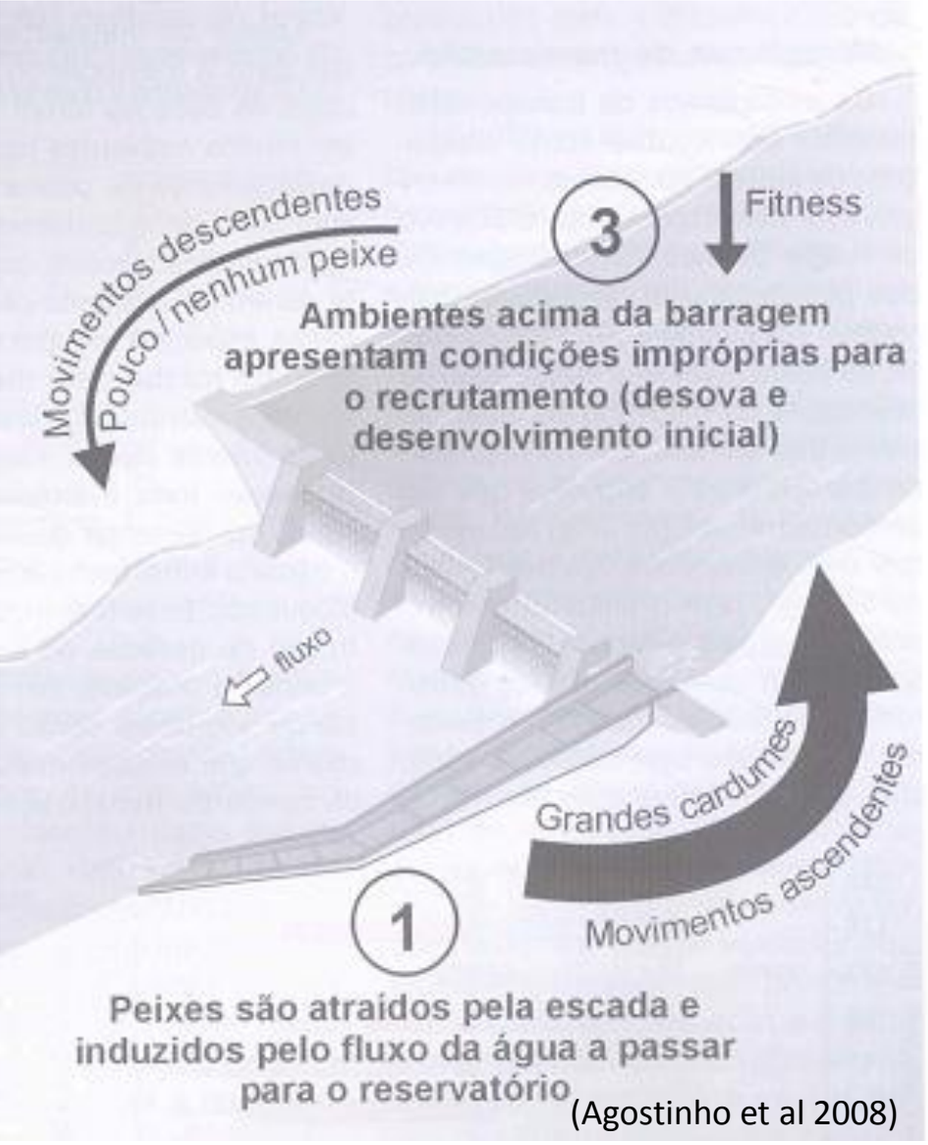
- Mainly in Neotropical region;

- Current concept → A great amount pass acending

  ↓

  Little or no fish come back to downstream

- However studies about descending movements are **scarce.**



(Agostinho et al 2008)

Aims

Therefore, this study aimed to reveal if the fish ladder **enable bidirectional connectivity** between downstream and upstream habitats for *Prochilodus lineatus.*

Specifically was evaluated:

1) Entry proportion by river bank for downstream and upstream

2) Passage proportion – Ascending and descending

3) Transit time – Ascending and descending

4) Seasonal differences in migration movements through fish ladder

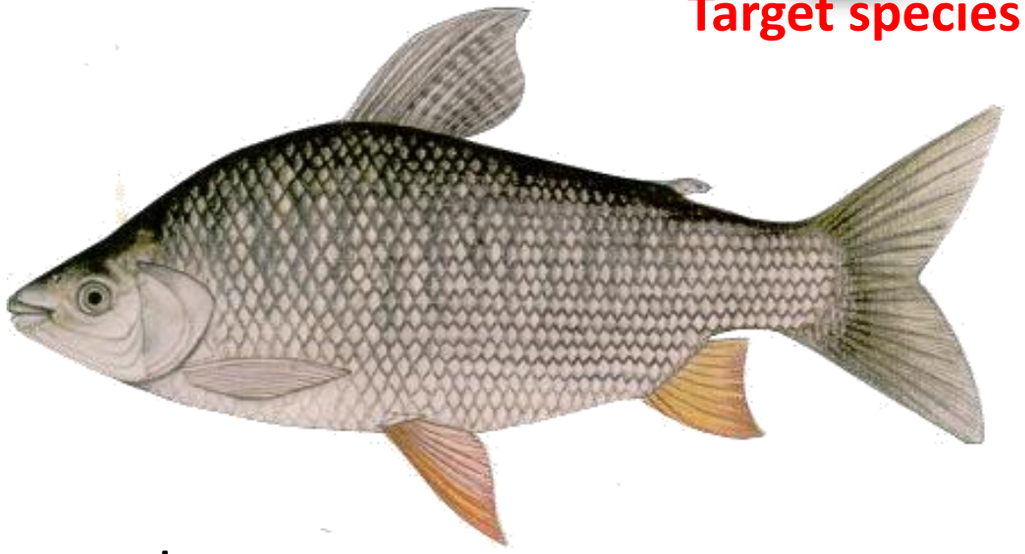
5) Long-term return patterns - To upstream and downstream

2. Methods

- This study was done with *Prochilodus lineatus* – Valenciennes, 1836.

Target species

- It is a potamodromous species from Paraná River:
  - May migrate up to 1.000 km;
  - May live up to 8 years;
  - Migration beginning around 2 years old;
  - The fish goes to tributaries where spawn;
  - Around 2 years the juveniles goes to main Channel.



Prochilodus lineatus
4.6 mm

In a recruitment process

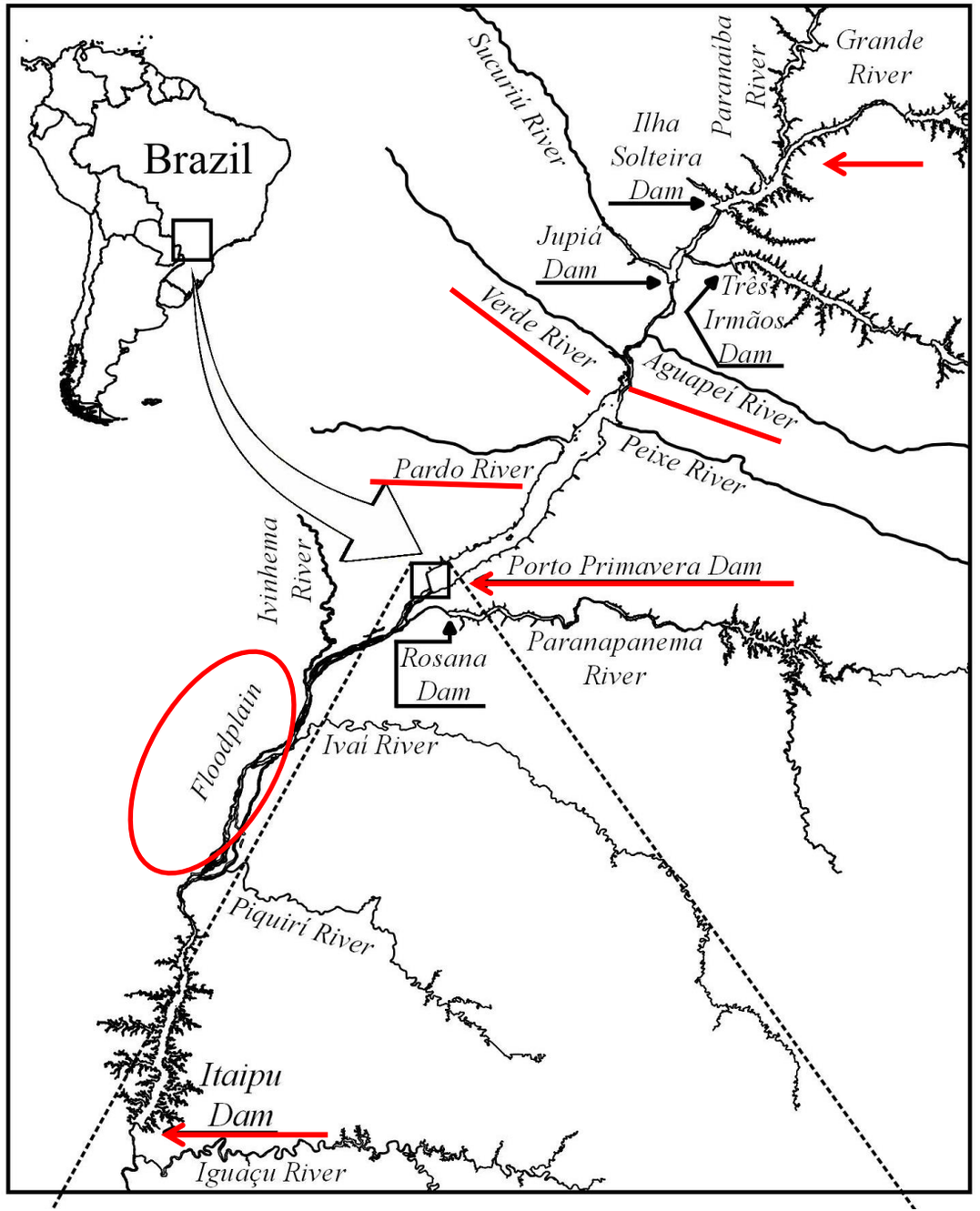
2.1. Study area

Paraná River is the 10° longest river

- Lower Paraná
- Middle Paraná
- **Upper Paraná**

-750 rkm

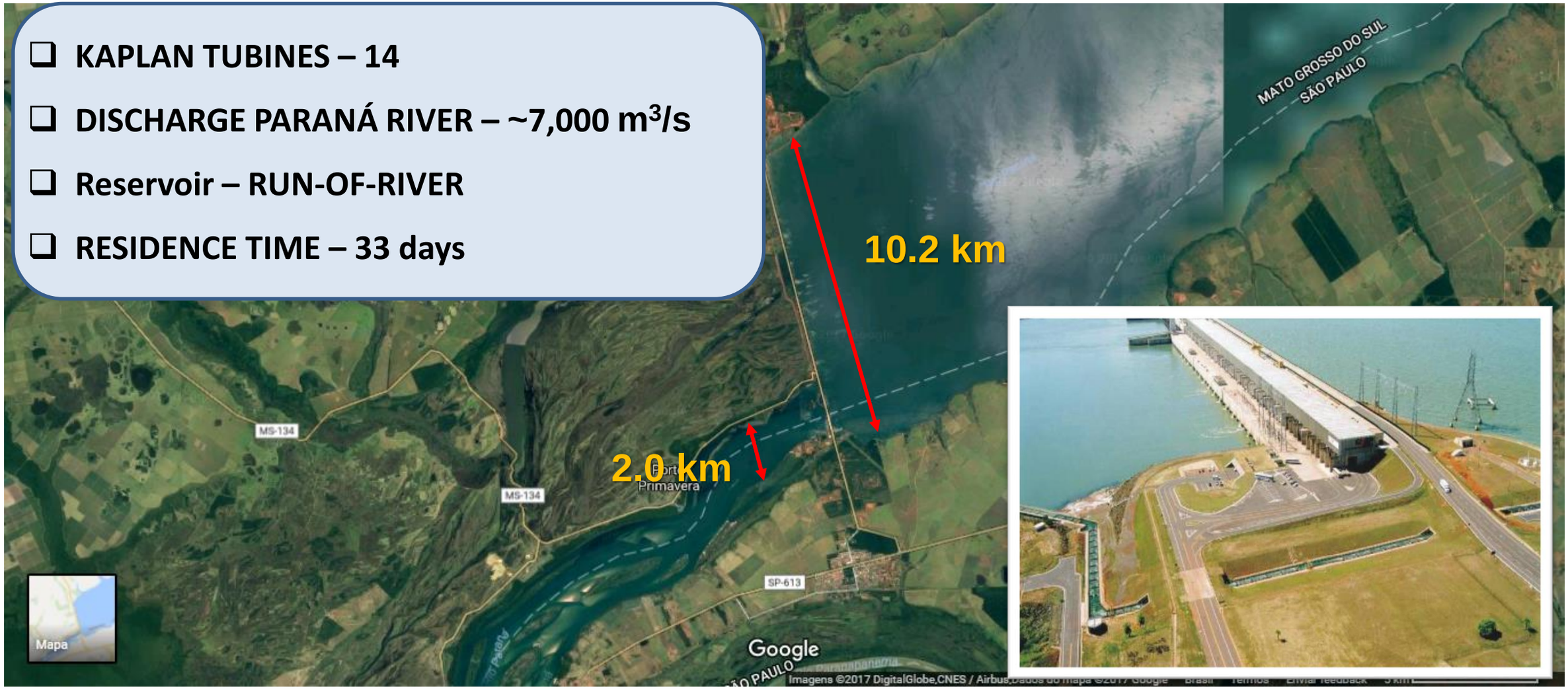
- Porto Primavera dam
- More than 310 fish species



2.1. Study area

HPP Engenheiro Sergio Motta – **Porto Primavera – Upper Paraná River**

- **KAPLAN TUBINES – 14**
- **DISCHARGE PARANÁ RIVER – ~7,000 m^3/s**
- **Reservoir – RUN-OF-RIVER**
- **RESIDENCE TIME – 33 days**

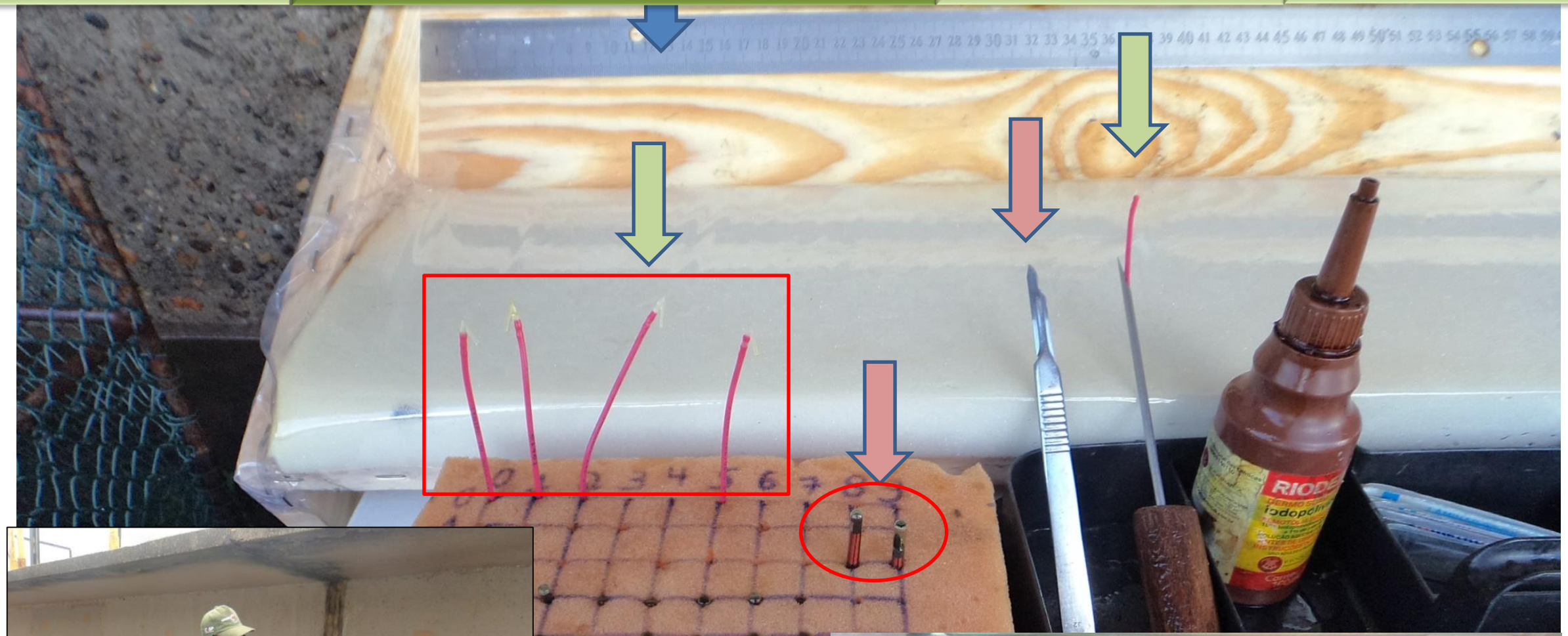


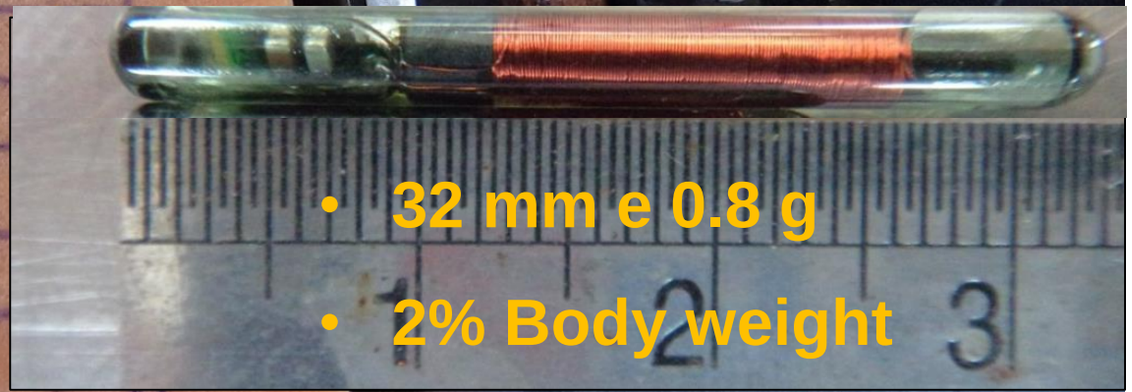
2.2 Fish ladder

- Built in 2001
- Pool and weir with bottom orifice
- 472 m long
- 4% slope
- 50 pools (5 x 8 x 1.4m)
- 3.0 – 3.5 $m^3 s^{-1}$

2.3 Fish capture, mark and release

2. Methods

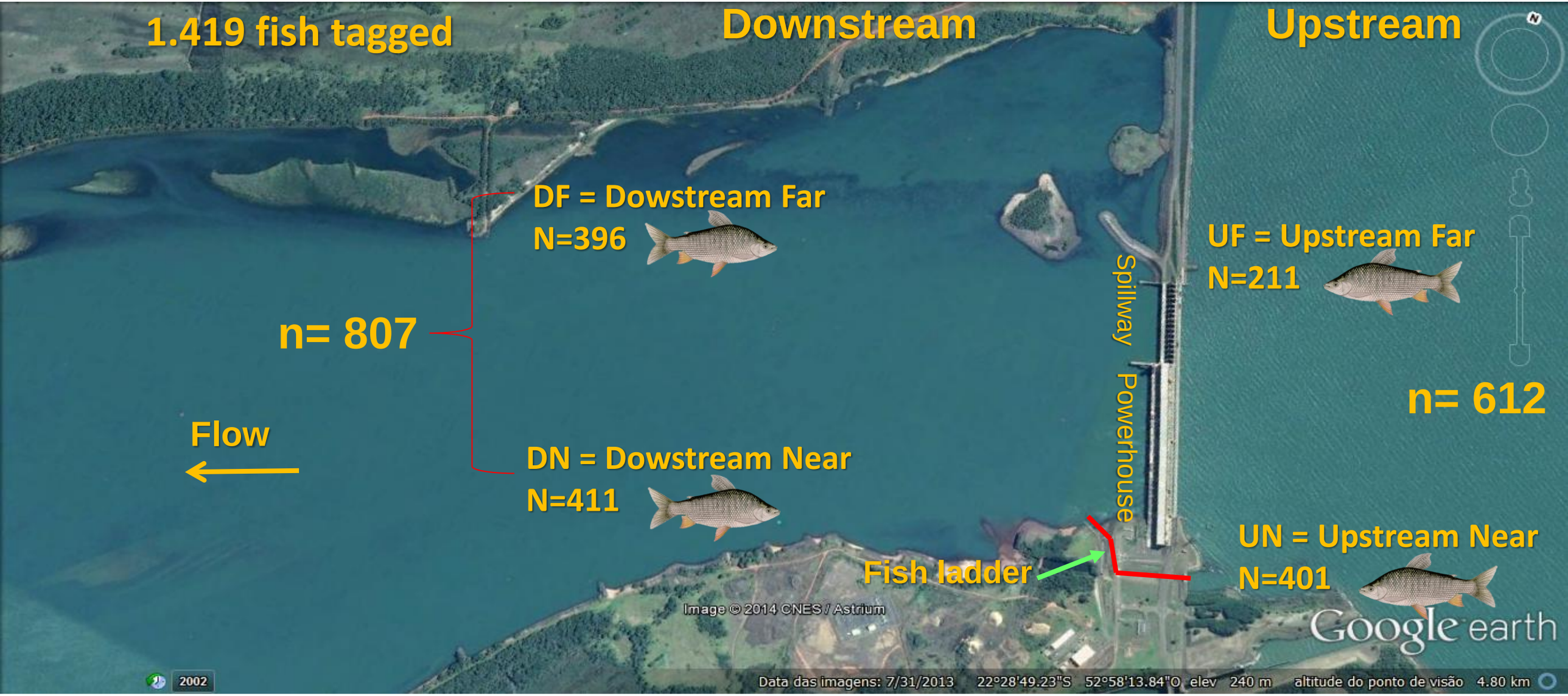




- 32 mm e 0.8 g
- 2% Body weight

2.3 Fish capture, mark and release

2.3 Fish capture, mark and release



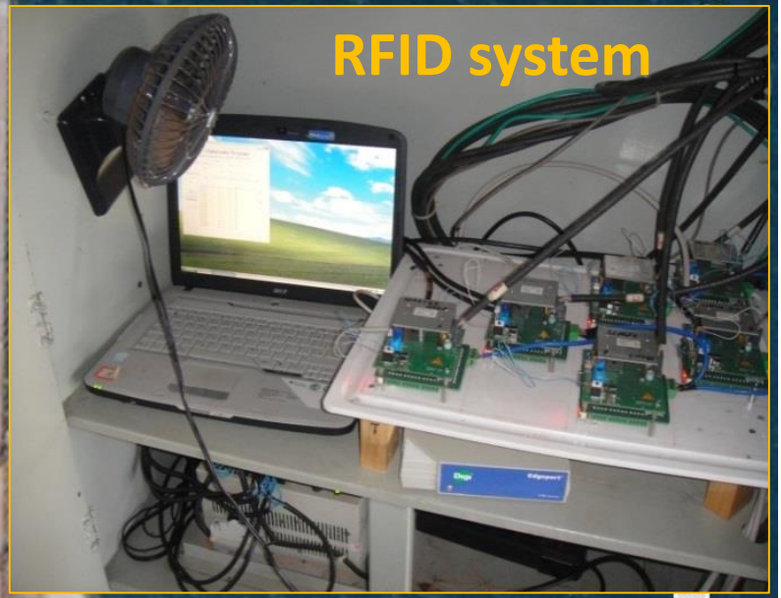
2.4 Monitoring

Over 4 years → From 2012 to 2016.

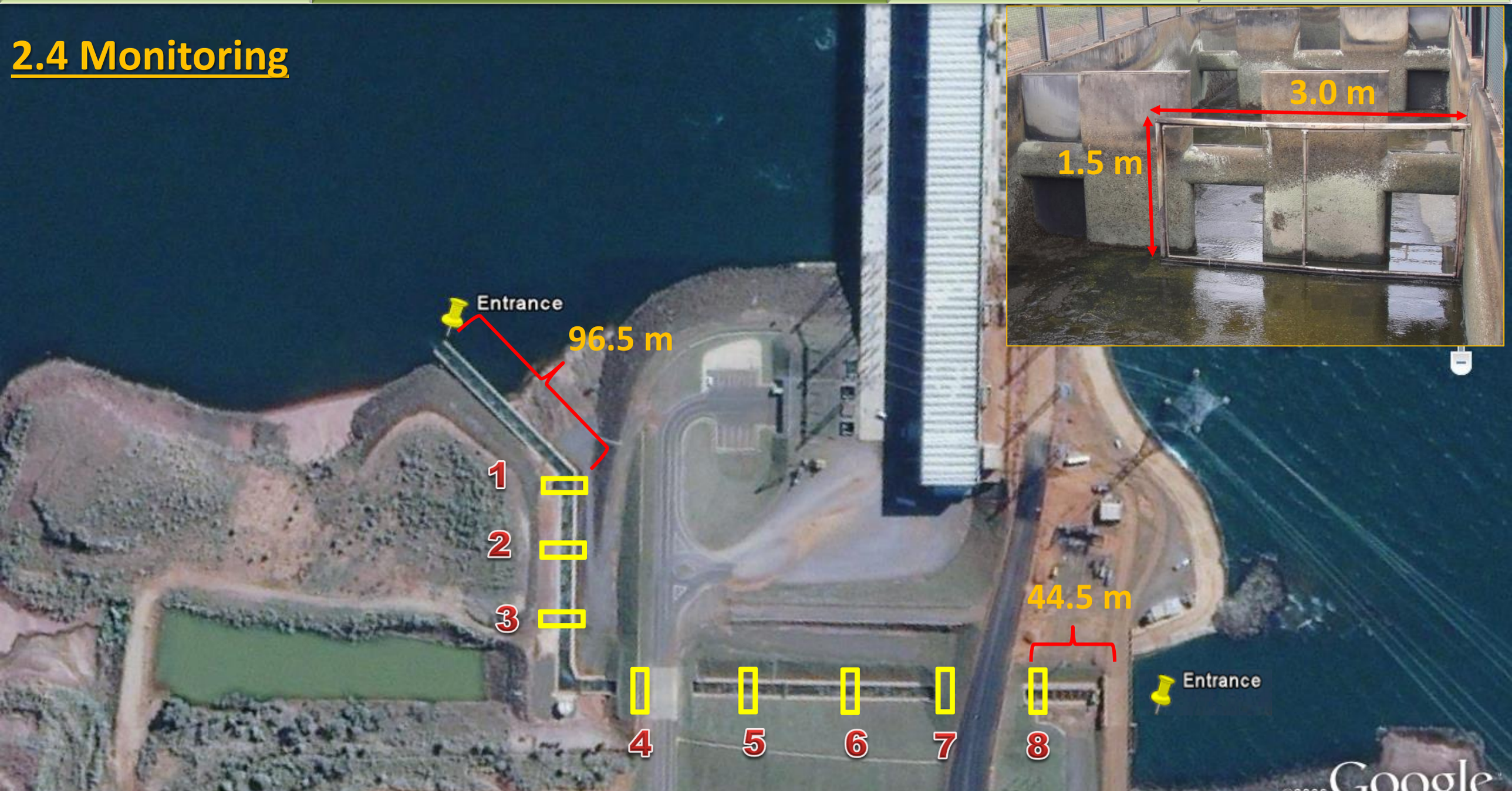
Including:

Four reproductive seasons (October- March)

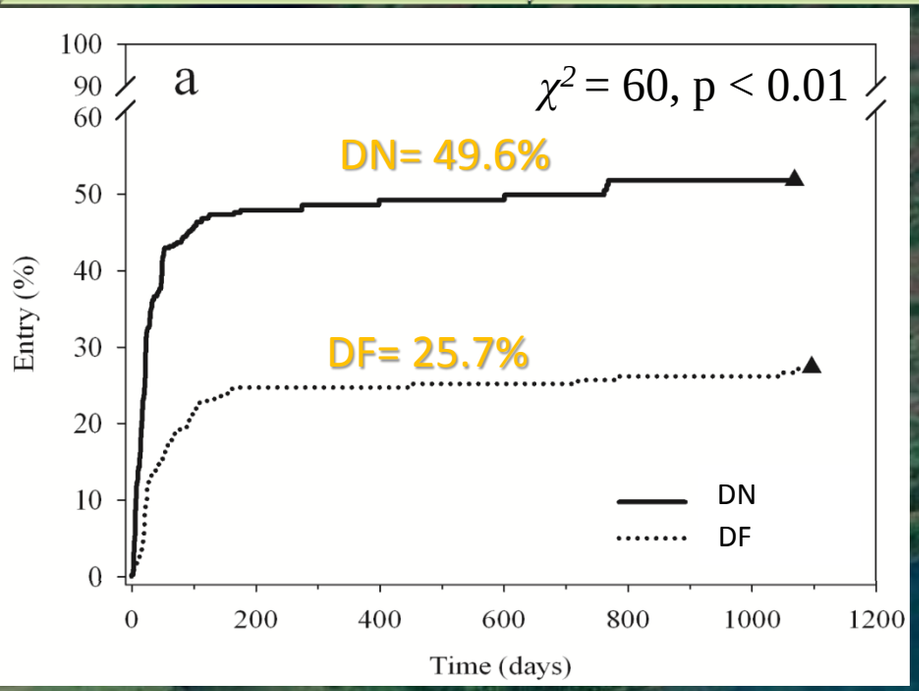
Four non-reproductive seasons (April – September)

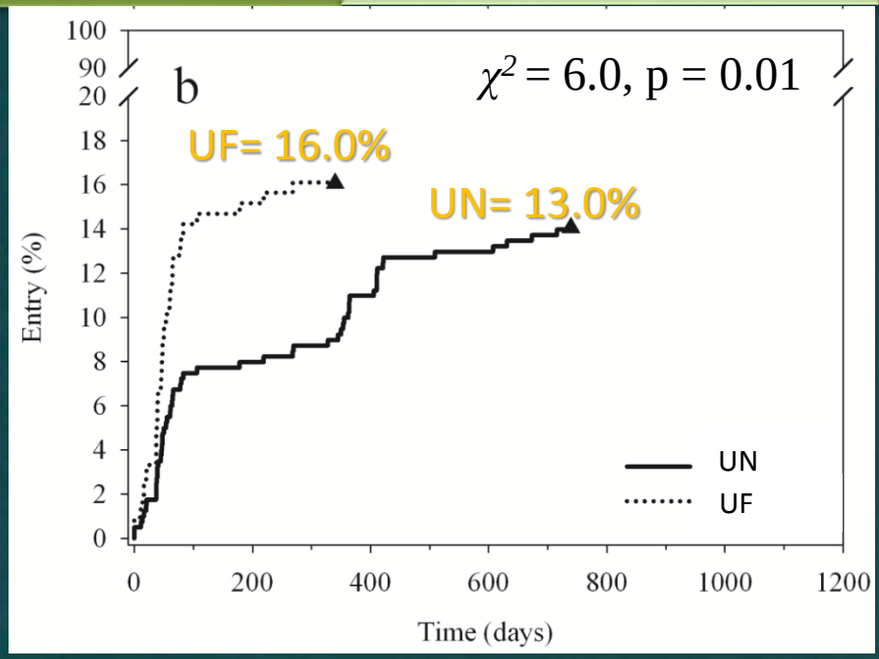


2.4 Monitoring



3.1 Entry to ladder





Median entry time
30.1 days

Median entry time
97.7 days

Median entry time
21.1 days

Fish ladder

Median entry time
243.5 days

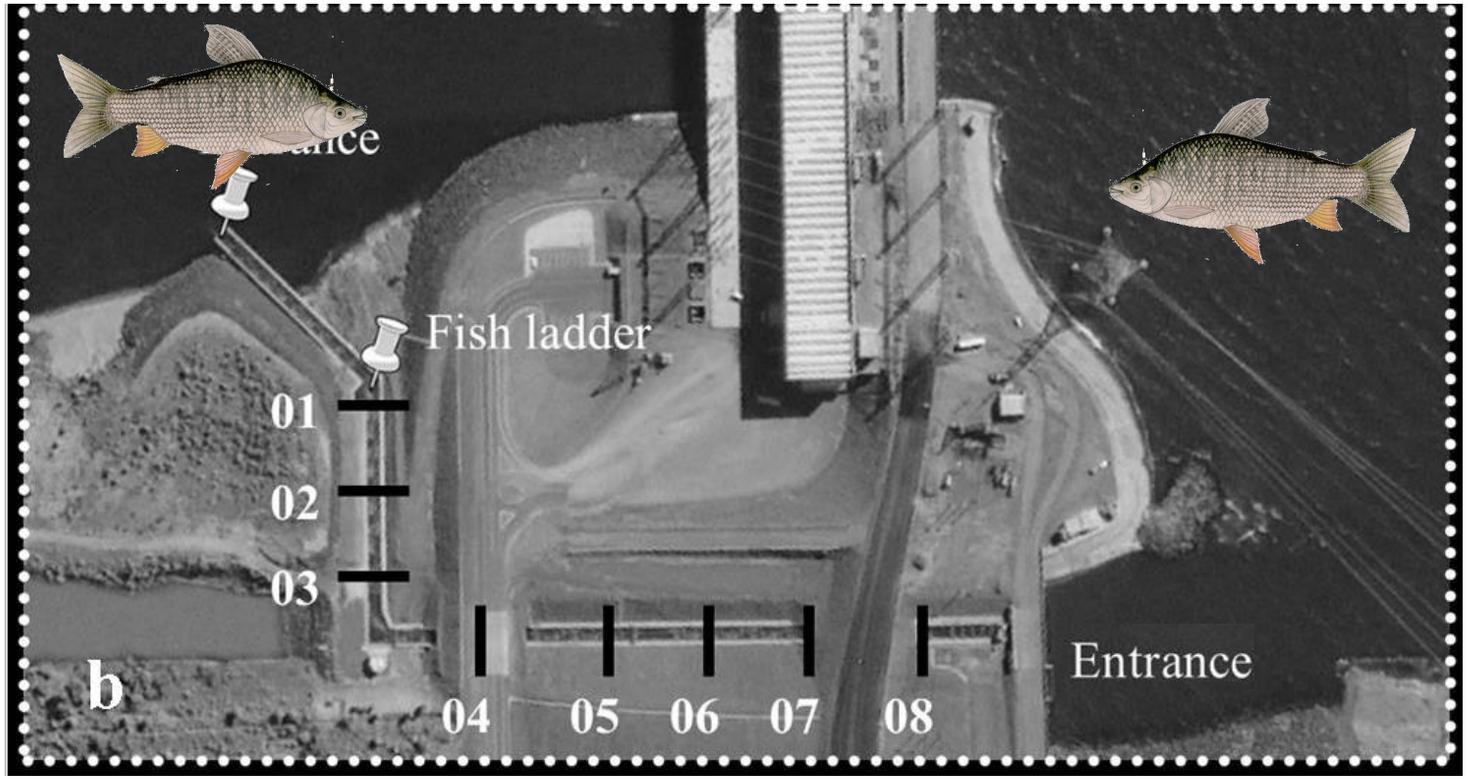
Google Earth

3.1 Entry to ladder and passage proportion

Downstream

807 tagged fish

306 entered



Upstream

612 tagged fish

86 entered

37.9 %

Likelihood ratio chi-square test
(x^2 = 104.7, p<0.01)

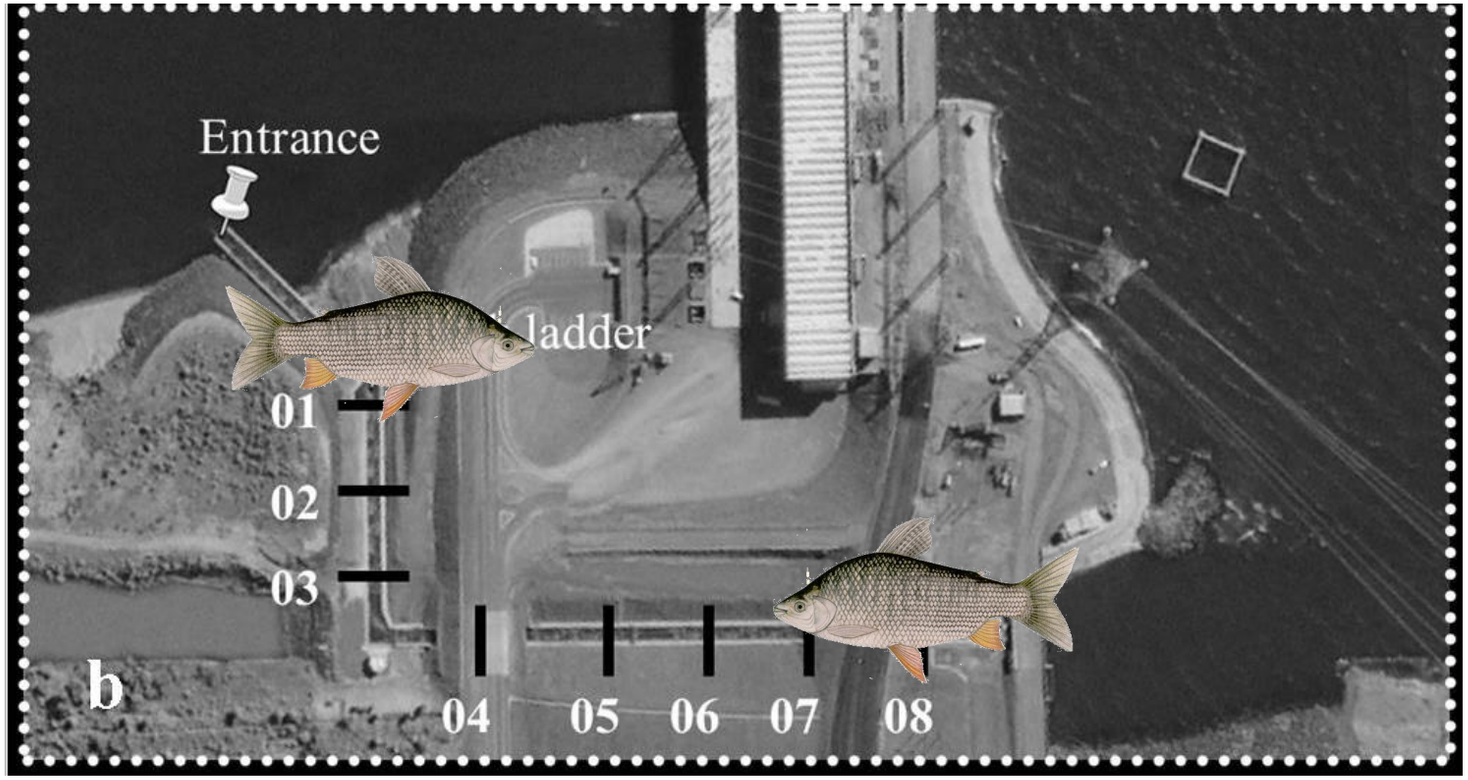
14.2 %

3.1 Entry to ladder and passage proportion

Downstream

807 tagged fish

306 entered



Upstream

612 tagged fish

86 entered

37.9 %

Likelihood ratio chi-square test
(x^2 = 104.7, p<0.01)

14.2 %

267 exit

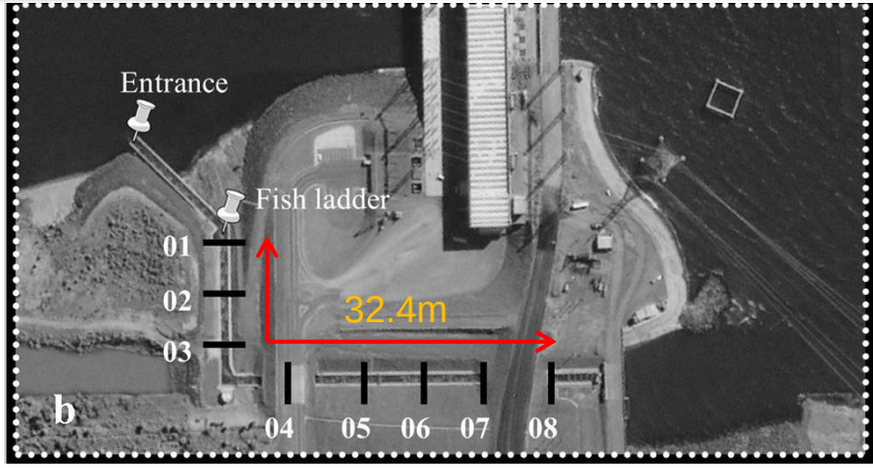
87.2 %

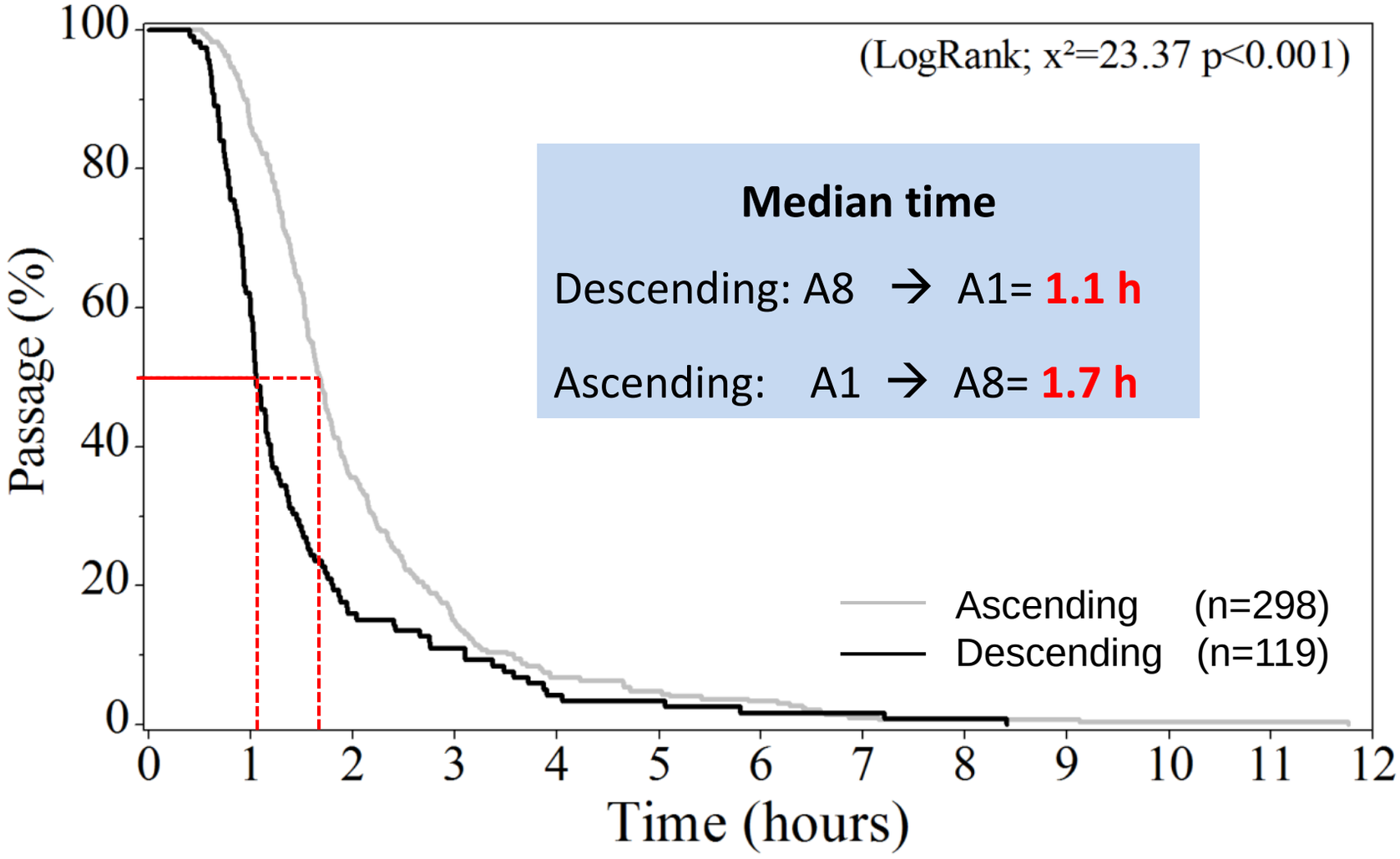
Likelihood ratio chi-square test
(x^2 = 0.8, p= 0.37)

90.7 %

78 exit

3.2 Transit-time through the ladder





Median time

Descending: A8 → A1= **1.1 h**

Ascending: A1 → A8= **1.7 h**

3.3 Season differences

452 passes

Reproductive season
(Octubre – March)

89.0%

Ascending: 73.7 % (n= 297)

Descending: 26.3% (n= 106)

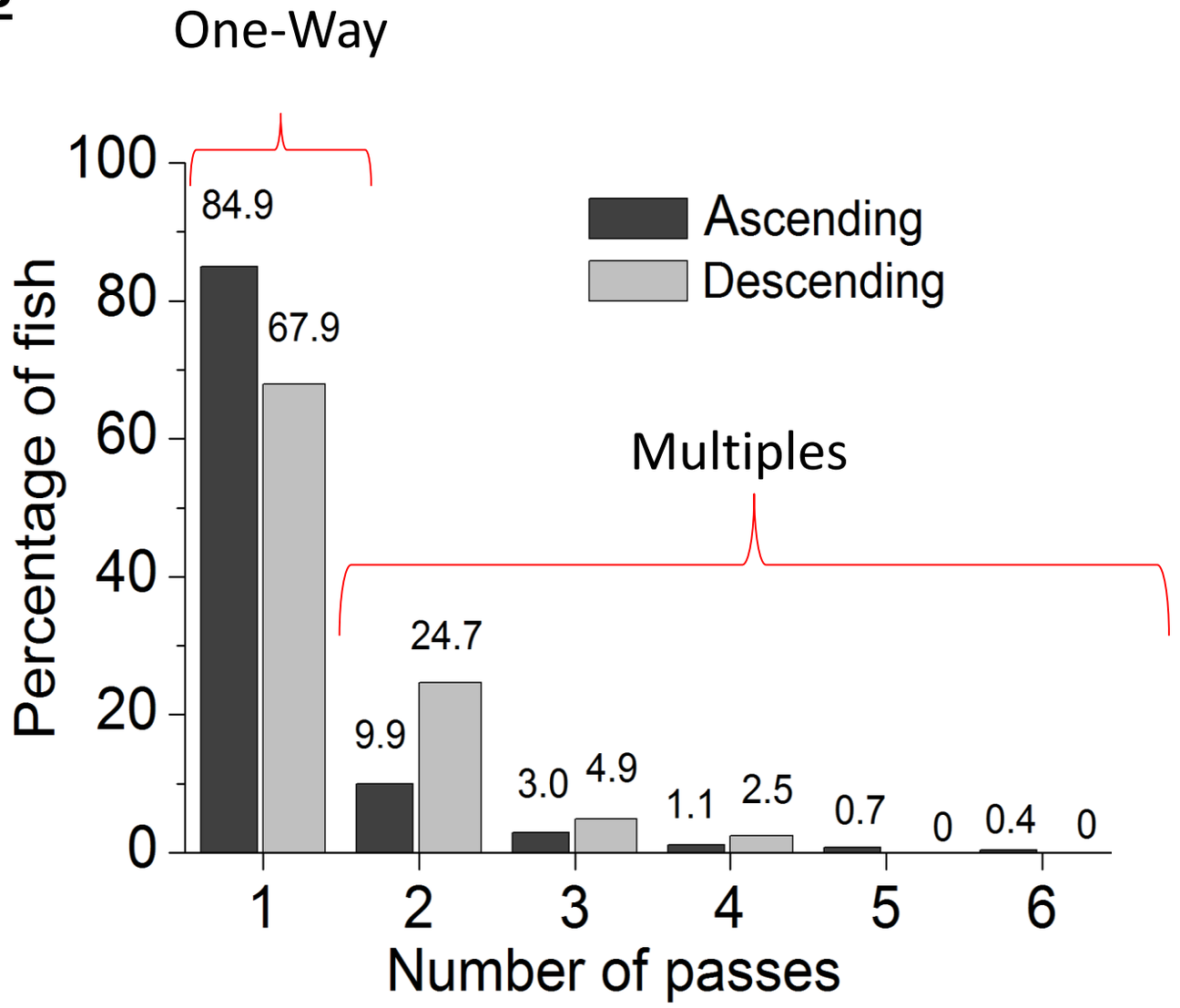
Non-reproductive season
(April – September)

10.1%

Ascending: 55.1% (n=27)

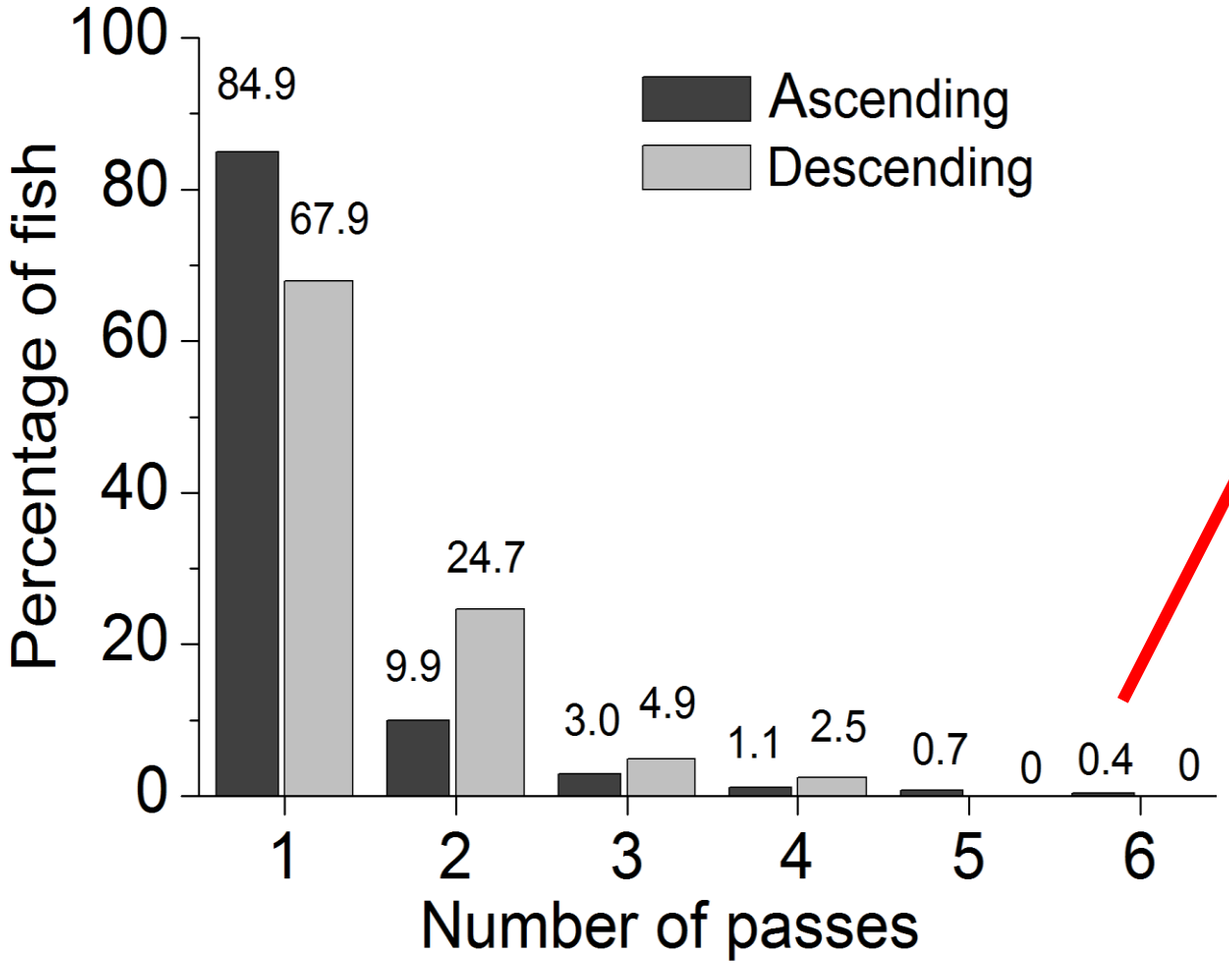
Descending: 44.9 % (n= 22)

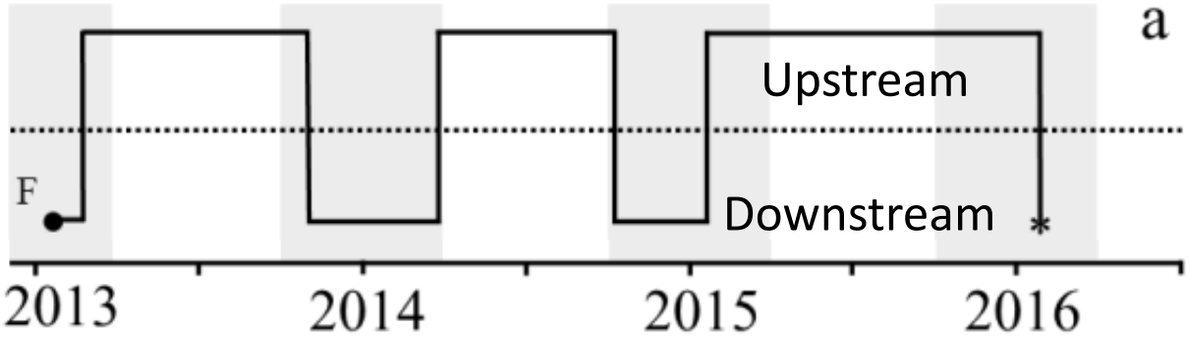
3.4 Return patterns



Percentage of fish ascending and descending through the fish ladder Dam in relation to amount tagged fish in upstream and downstream. fish made 1, 2, 3, 4, 5, and 6 passes .

3.4 Return patterns





Percentage of fish ascending and descending through the fish ladder Dam in relation to amount tagged fish in upstream and downstream. fish made 1, 2, 3, 4, 5, and 6 passes .

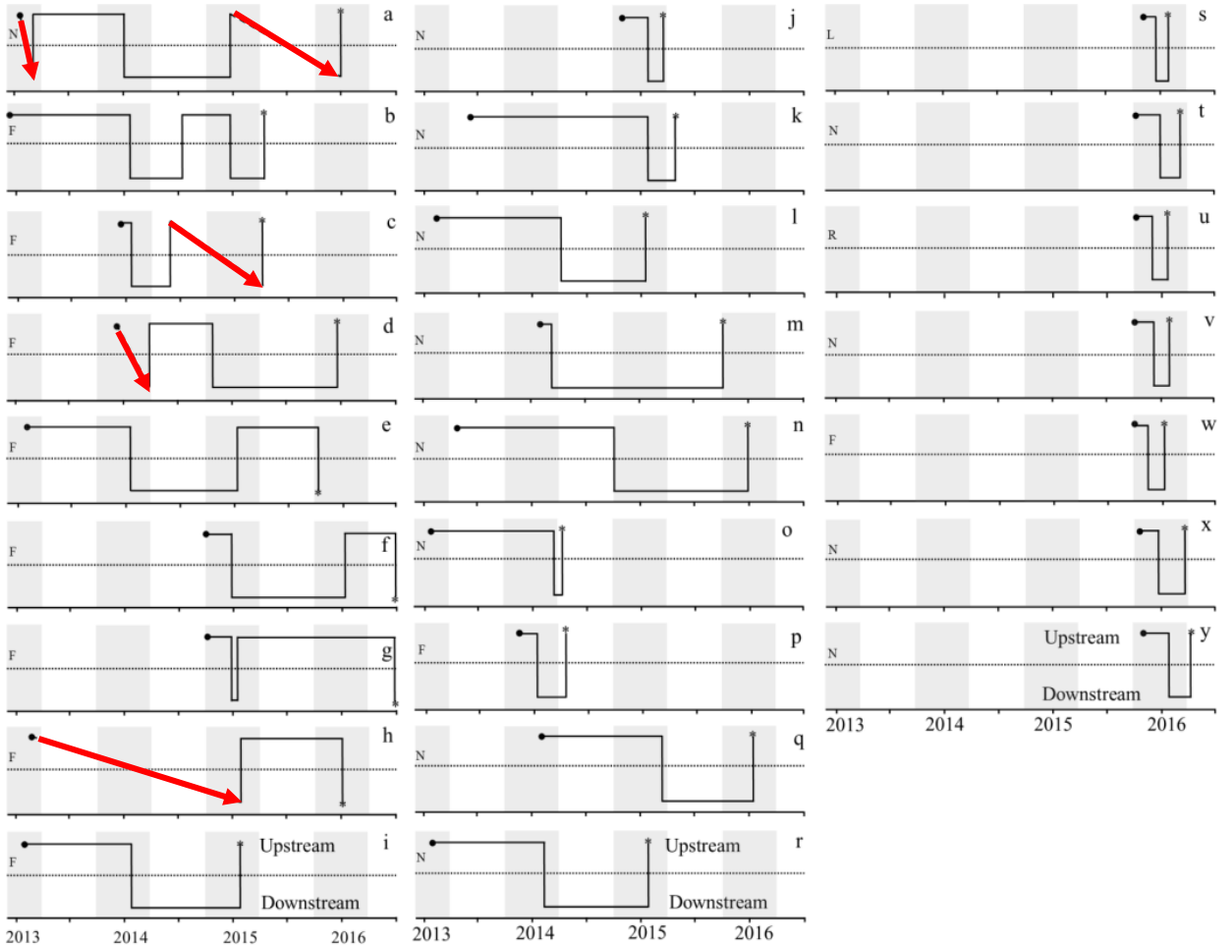
3.4 Return patterns

N= 67 fish

- Turbines - Spillways -Navigation lock

Fish released in **Downstream**

Fish released in **Upstream**

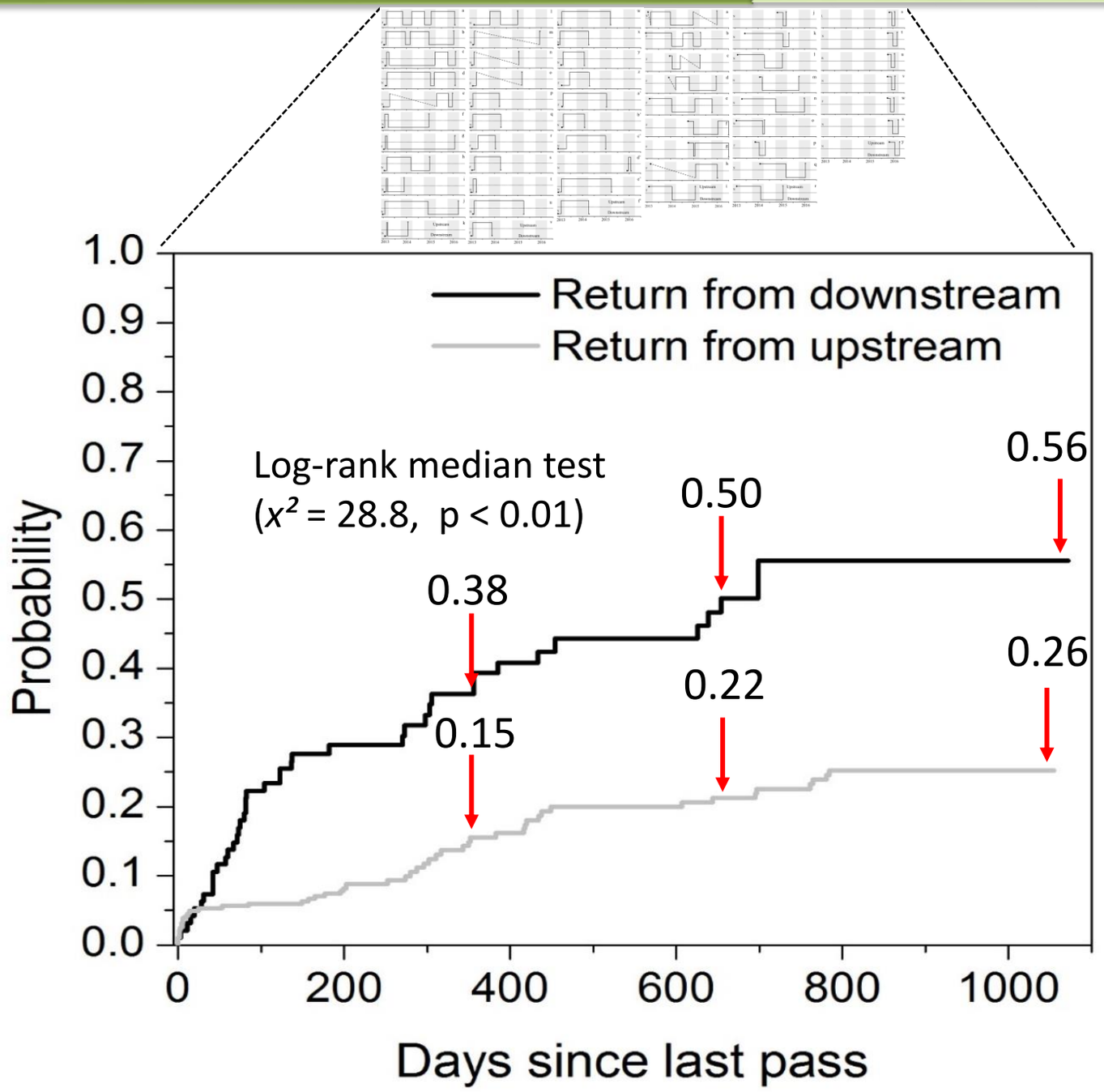


3.4 Return patterns

Annual migration

Migration 2-3 years

- Tributaries and floodplain
- Partial migration



3.4 Return patterns

The fish return faster from downstream than from upstream.

Return from downstream

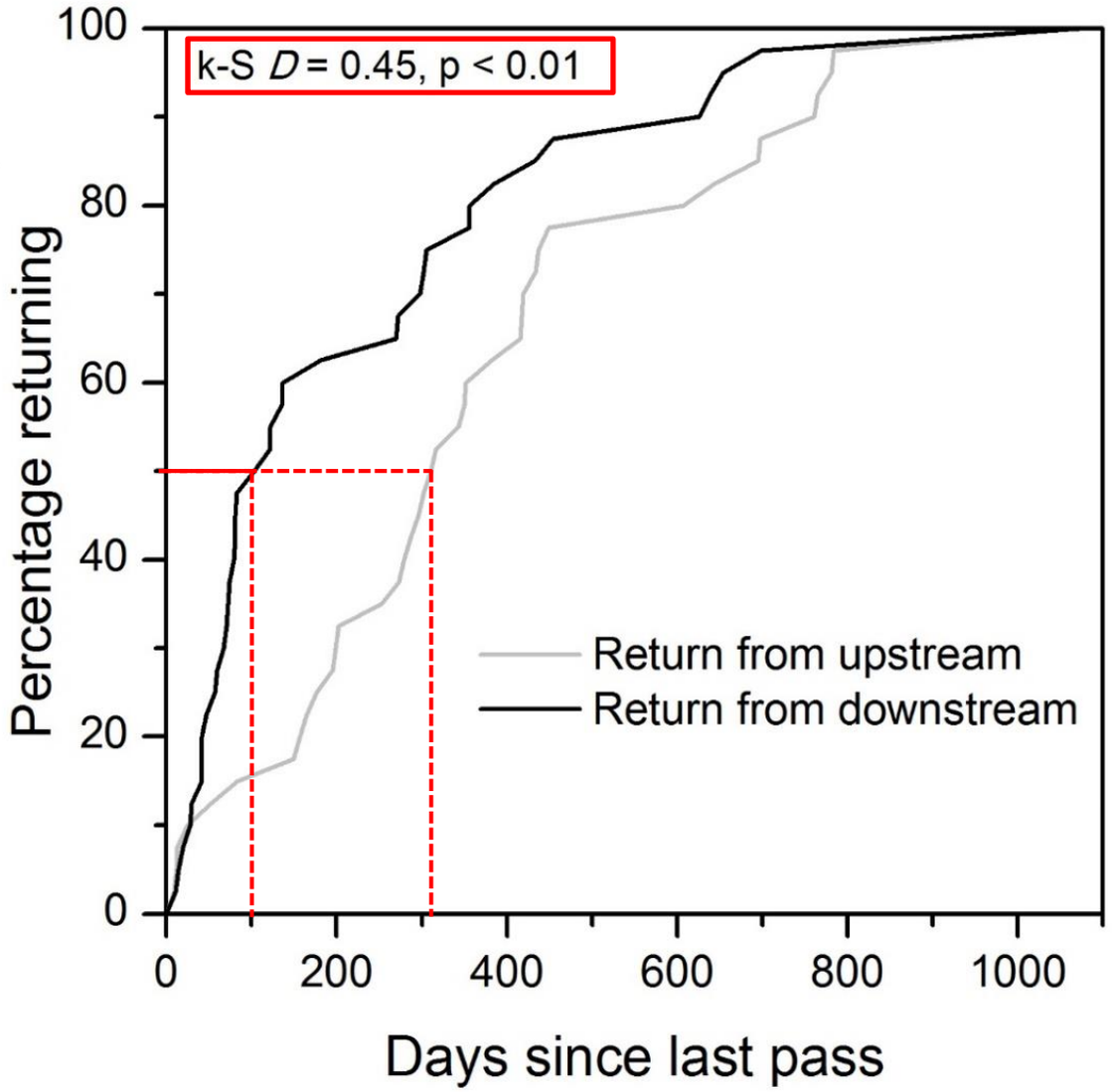
Median= **100 days**

Range: **9 – 1.055 days**

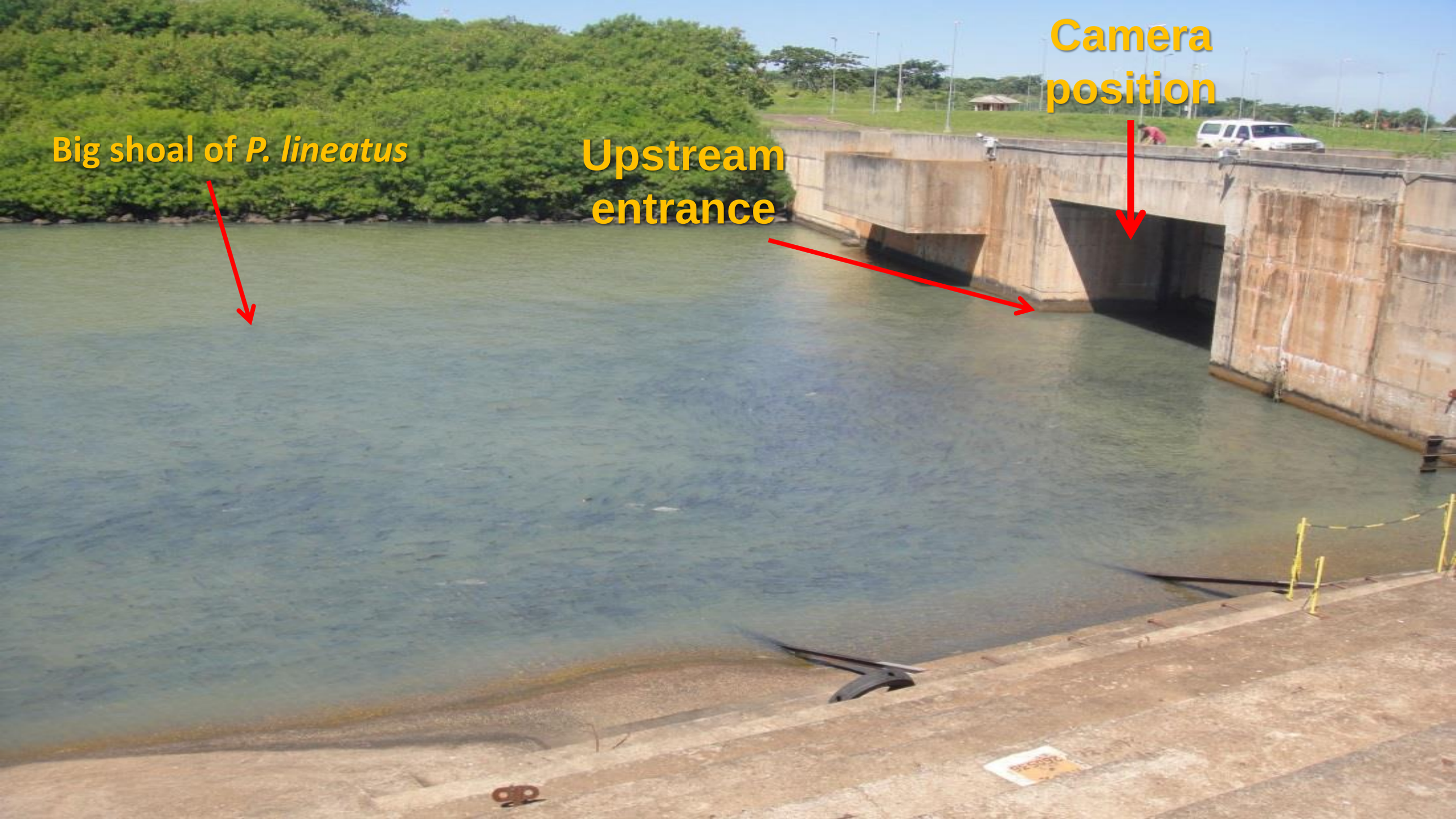
Return from upstream

Median= **310 days**

Range: **11 – 1.071 days**



Cumulative percentage of *Prochilodus lineatus* returning from downstream (black line) and upstream (gray line) habitats to the Porto Primavera Dam fish ladder. The two curves were compared with the nonparametric Kolmogorov-Smirnov test. Fish that returned within seven days were not shown.


Big shoal of *P. lineatus*
Upstream entrance
Camera position

- **The fish ladder can provides bidirectional connectivity for *Prochilodus lineatus*.**
- **Some fish species, like *Prochilodus lineatus*, has great ability to use the fish ladder in both directions.**
- **Fishway science in Neotropical rivers need more attention about fishway desing in attempt to provides and improve downstream passage.**

ACKNOWLEDGEMENTS

- Companhia Energética de São Paulo – CESP:
  - Financial and logistic support;

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THANK YOU!

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